Progress Report

1. Shelby Frisch

2. IA #DE-AI03-97ER62342 “Ground-Based Retrieval of Arctic Stratus and Altostratus Cloud Microphysical and Turbulence Parameters”

3. Scientific Goals

The main goals are: 1) Calculate microphysical properties of spring and summer stratus clouds in the Arctic with a focus on using the results in cloud models. This work would target any suitable clouds from SHEBA or from NSA. 2) Continued validation of stratus cloud retrieval technique, particularly the effective radius retrieval. 3) Continued development of the retrieval technique through the blending of the Frisch et al. 1995 technique with other techniques. 4) Distributions of vertical velocities and turbulence parameters will be determined for Arctic stratocumulus clouds.

4. Accomplishments

- Retrieval of arctic radar data sets for cloud microphysical properties. Paper accepted by JGR. “Cloud Water Contents and Hydrometeor Sizes During the FIRE-Arctic Clouds Experiment” by Shupe, Uttal, Matrosov, and Frisch.
- Comparisons of radar retrievals of effective radius vs. aircraft FSSP estimates of effective radius. Paper in preparation.

5. Progress and accomplishments in the last twelve months.

Arctic work

We have used the cloud radar measurements that were taken from April-July 1998 during

SHEBA. This was the NASA/FIRE - Arctic Clouds Experiment. We used retrieval techniques that were developed by Frisch et al. 1995, which combined the NOAA MMCR and microwave radiometer shipboard measurements. We found that the all-liquid cloud retrievals had a mean effective particle radius of 7.4 microns, and a liquid water content up to 0.7 gm^{-3} with a mean particle concentration of 54 cm^{-3}. The maximum retrieved liquid water content was at 3/5 of the cloud depth above cloud base. In order to compare the representativeness of the aircraft FIRE-ACE aircraft flight days with the April-July months, retrieval statistics of flight-day clouds were compared to the mean retrieval statistics. The retrieved liquid cloud parameters during flight days were about 20% smaller than the mean statistics. Figure 1 shows a sample of the retrievals of cloud microphysical properties for an arctic stratus cloud.

Retrieval Improvements

The FSSP aircraft data from the April 1997 IOP along with the NOAA Ka-band radar and the SGP microwave radiometer was used to compare the radar effective radius retrievals with those measured with the FSSP. We had one day where the NOAA Ka-band radar polarization measurements showed that there were no bugs to contaminate the radar backscattered power measurements, which is a critical parameter in the effective radius retrieval. These effective radius retrievals were based on Frisch et al. 1995 stratus cloud retrieval methods, which uses combined measurements of cloud radar reflectivity and the microwave radiometer integrated cloud liquid water. The technique assumes a log-normal droplet distribution, droplet concentration and spread constant with height, and that the spread is known. Using this information, we compared the radar-radiometer effective radius retrieval with the FSSP calculated effective radius. The standard deviation of the difference between the retrieved effective radius and the aircraft measurements is 1.1 microns; however, there is a wide spread in the differences, which is related to the backscattered power. Figure 2 shows the absolute effective radius difference in the measurements by the FSSP and the radar-radiometer retrievals

as a function of radar reflectivity. The figure shows that above -30 dBZ, the differences in the effective radius retrieval with the FSSP measurements are less than 0.5 microns; however, there is a rapid increase in the difference at reflectivities lower than -30 dBZ. The retrieval is sensitive to the retrieved droplet density and less to the spread of the logarithmic distribution. Figure 3 shows how the radar retrieved and the FSSP measurements of absolute droplet density differences vary as a function of dBZ. The differences are relatively small above -30 dBZ while below -30 dBZ, they become quite large. These large differences below -30 dBZ could be due to several factors such as radar calibration, microwave radiometer errors as well as errors in the FSSP. These factors are being investigated. We will have additional verification data in the SHEBA data sets.

6. Attached figure.

7. Refereed Publications

Frisch, Martner, Dialalova, and Poellot, 2000. "Comparison of radar/radiometer retrievals of stratus cloud liquid water content profiles with in situ measurements by aircraft." Accepted by *J. Geophys. Res*.

Schupe, Uttal, Matrosov, and Frisch, 2000. "Cloud water contents and hydrometeor sizes during the FIRE-Arctic cloud experiment." Accepted by *J. Geophys. Res*.

Feingold, Frisch, Stevens, and Cotton, 1999. "On the relationship among cloud turbulence, droplet formation and drizzle as viewed by Doppler radar, microwave radiometer and lidar. *J. Geophys. Res*., **104**, 22,195-22,203.

8. Extended abstracts. None.

9. None

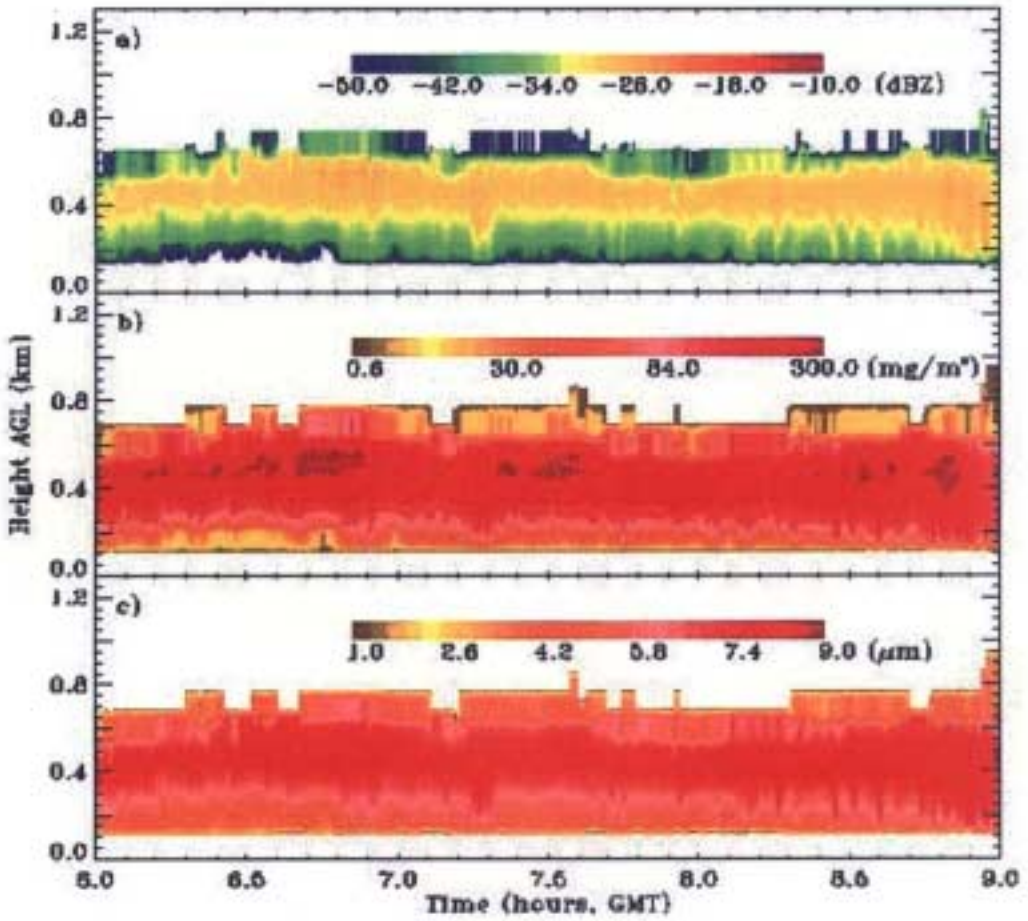


Figure 1. A three-hour period from 6:00 to 9:00 GMT on June 4, 1998 demonstrates the liquid cloud retrieval products. This time period consisted of a fairly stable stratus layer with cloud top near 700m. Radar reflectivity, the key radar measurable for these retrievals, is shown in Figure 1a, retrieved LWC is shown in figure 1b, and retrieved Re is shown in Figure 1c.

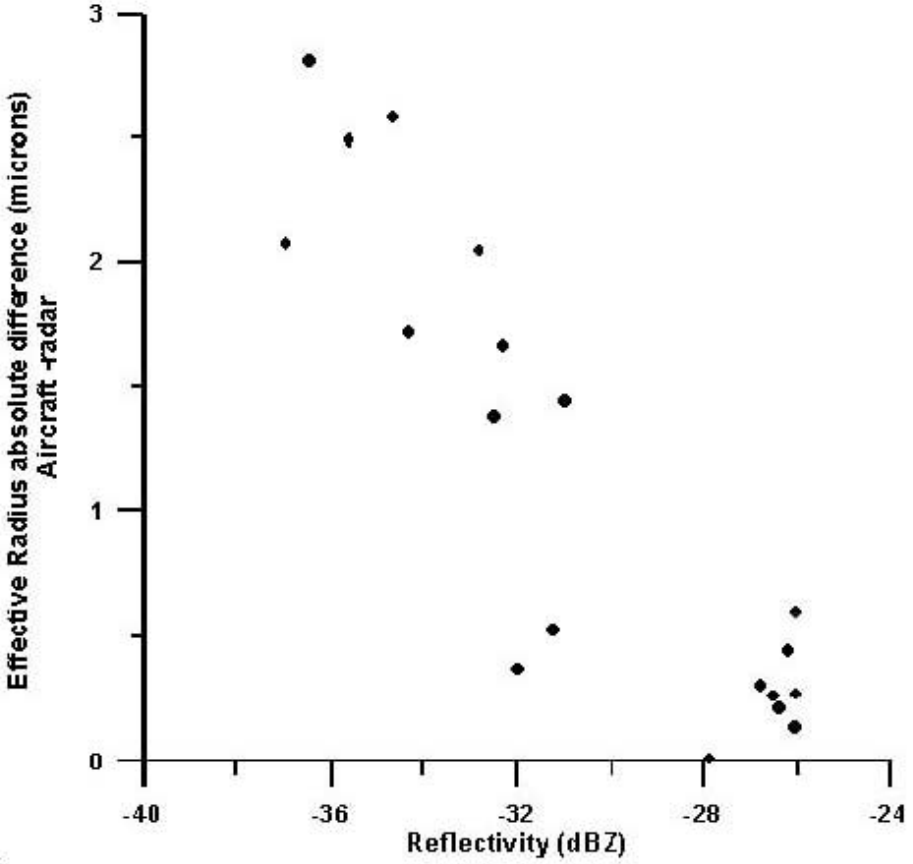


Figure 2

Absolute difference between the aircraft FSSP determined effective radius and the radar-radiometer retrieved effective radius as a function of the radar reflectivity.

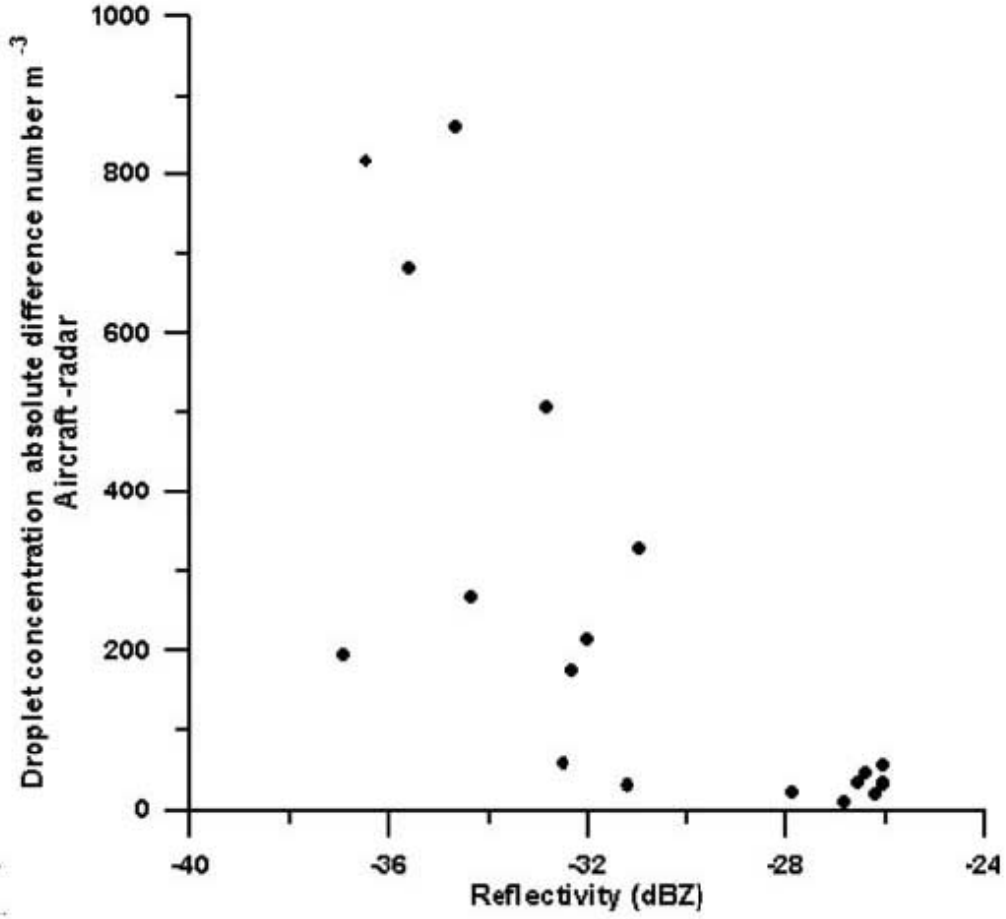
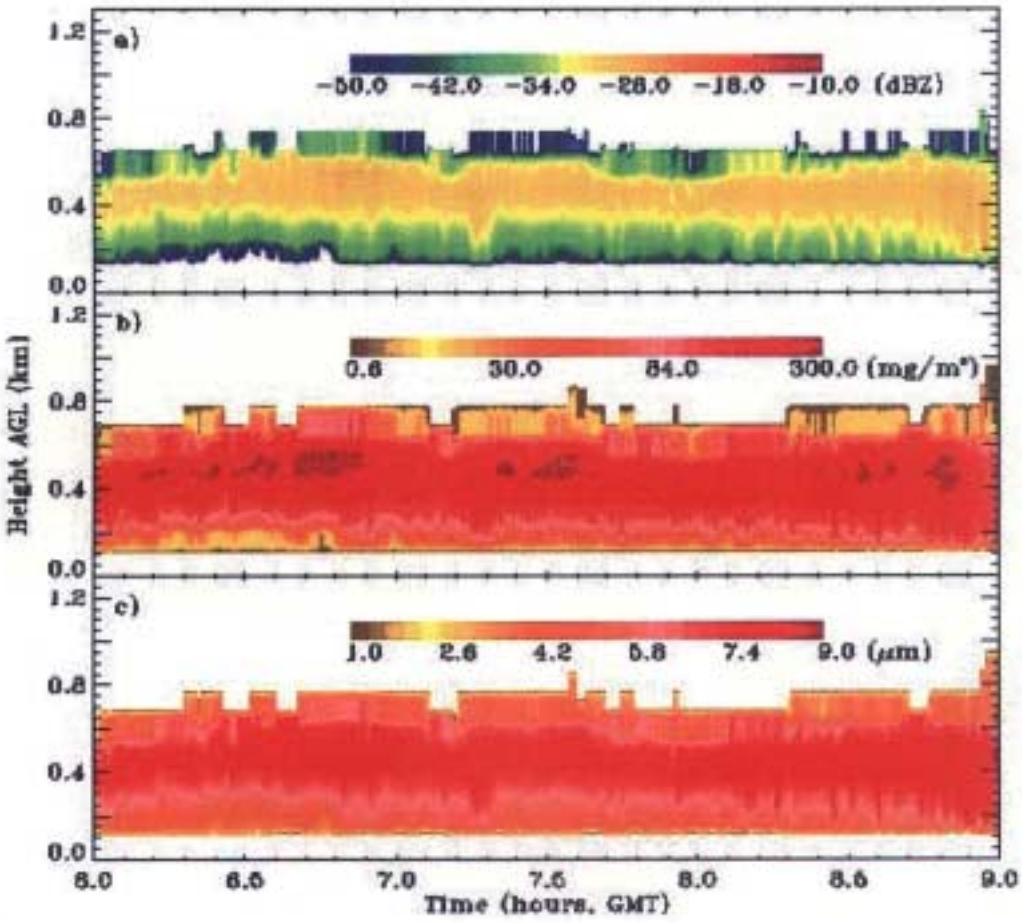


Figure 3.
Absolute difference between aircraft FSSP measurements of cloud droplet concentration and radar-radiometer retrieved concentration as a function of radar reflectivity.



This is an example taken during the year-long Surface Heat Budget of the Arctic Experiment (SHEBA) (1997-1998). It is a three hour period from 6:00 to 9:00 GMT on June 4, 1998 which demonstrates the liquid cloud retrieval products. This time period consisted of a fairly stable stratus layer with cloud top near 700m. Radar reflectivity, the key radar measurable for these retrievals is shown in Figure 1a, retrieved LWC is shown in figure 1b, and retrieved Re is shown in Figure 1c. The radar used for SHEBA was the NOAA millimeter cloud radar aboard an Ice Breaker which was frozen in the Arctic ice pack.